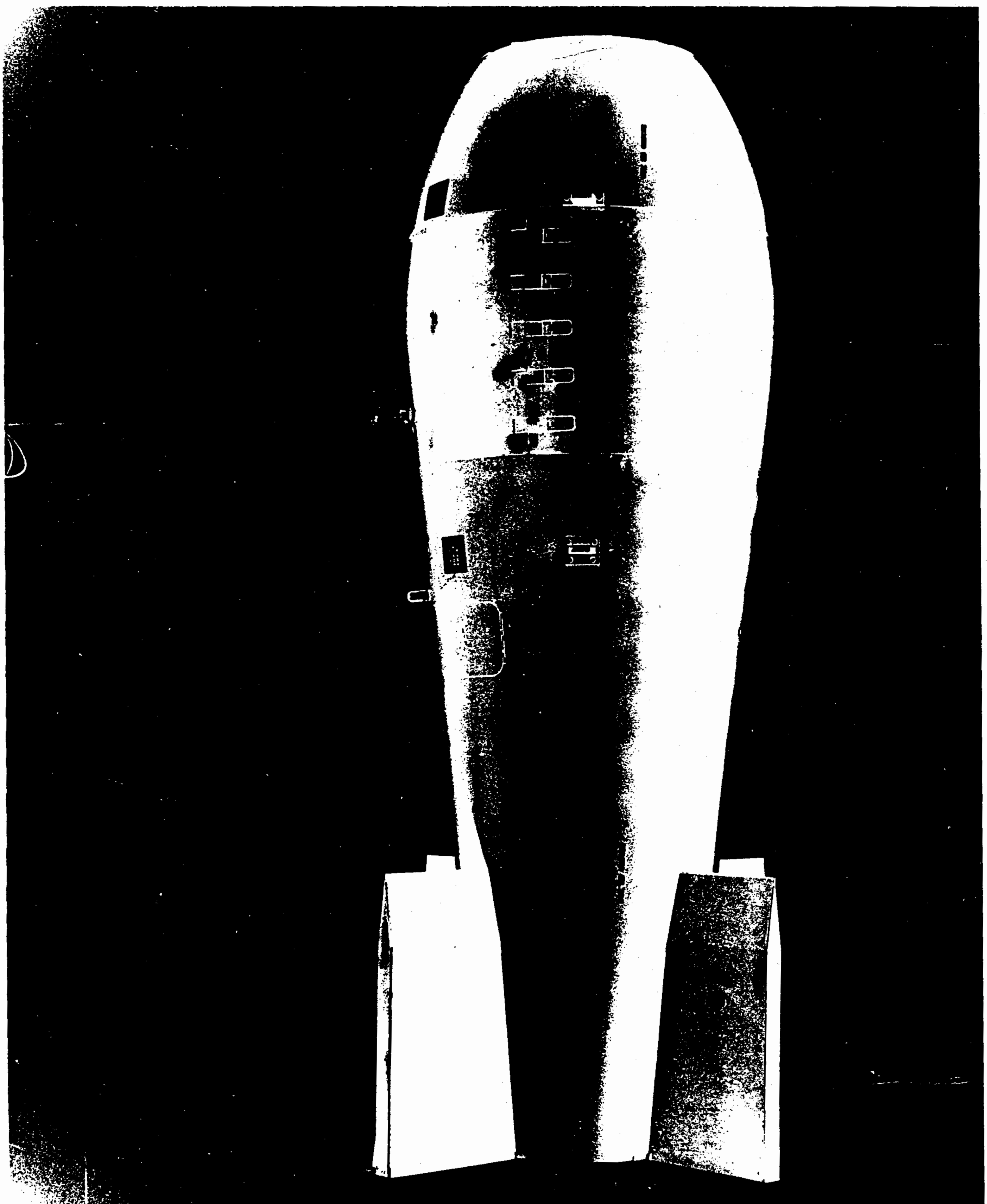

Mark 5 Bomb - Exterior View

TIMETABLE OF MK 5 BOMB EVENTS

1946-7	Nuclear studies of small implosion device begun.
10-31-47	Military Liaison Committee requests design of smaller and lighter implosion bomb.
1948	Los Alamos Scientific Laboratory makes detailed nuclear studies of small device.

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HISTORY OF THE MK 5 BOMB

The feasibility of creating a small implosion bomb was one of the weapon concepts studied by the Los Alamos Scientific Laboratory after the end of World War II. The over-all size of the wartime Fat Man device (which was to be as large as possible) had been established by the dimensions of the B-29 bomb bay and the existing state of implosion theory, and the resulting weapon was a bomb with reasonably high nuclear efficiency, but which was difficult to handle due to its bulk and weight (60-inch diameter; 128-inch length; 10,900-pound weight). Consequently, calculations were made of compressions produced by small-diameter high-explosive spheres, and different arrangements of nuclear material were studied.

This small implosion design was of interest to the Military, and the Military Liaison Committee informed the Atomic Energy Commission October 31, 1947, that current implosion bombs did not lend themselves to wide or flexible employment, and that a weapon both lighter and smaller than the Mk 4 (then in design) would be of considerable military importance.[1] The Atomic Energy Commission, in replying to this letter on December 10, 1947, pledged support of a vigorous program to develop a small bomb.[2]

Meanwhile the Division of Military Application wrote to Santa Fe Operations Office November 25, 1947, noting that any reduction in bomb weight would result in an increased range of the carrying aircraft and pointed out that: "Reduced dimensions might open up an entire new field of flexibility in the employment which could be a decisive influence in the military capability of getting the bombs home in war." [redacted]

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During 1948, it became apparent that determination of size, shape and weight for the lighter and smaller weapon required an understanding of military aircraft, delivery plans and problems. A conference was consequently held at Los Alamos September 2 and 3, 1948, which was attended by representatives of the Military, AEC weapon laboratories, and cleared members of the aircraft industry. It was decided that a bomb with a diameter of 40 to 48 inches and weighing between 5000 and 6000 pounds would cause significant improvement in aircraft performance and increase the probability of successful weapon delivery. It was felt that the length of the weapon should be retained at 128 inches.[4]

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During the foregoing study period, the project had been known as the Small Weapon Program and was directed by the Los Alamos Committee for Weapon Development. It was subsequently transferred, October 11, 1948, to the W (Weapon Development) Division of Los Alamos with the request that this Division undertake an "experimental, calculational, and fabrication program aimed at the production of a specific model of a complete small weapon for test early in 1951."[6]

The Committee for Weapon Development and the Military Liaison Committee had previously determined that the yield should be [redacted] kilotons; nuclear safing was mandatory; fuzing requirements should be based on the results of a height-of-burst study then in process; and the bomb should be an internally carried, free-fall, air-burst weapon.

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The work of the W Division almost immediately involved the Sandia Branch of the Los Alamos Scientific Laboratory and, it was suggested that a Steering Committee be established to direct development work on the weapon.[7] This new group initially met November 3, 1948, and the Chairman noted that much confusion had previously arisen due to various terms used to identify a given weapon, and suggested that a standard weapon name as well as a designation for the Steering Committee be established.[8] Mk IV nomenclature had already been assigned, so it was logical to use the next number, Mk V, for this device. The Committee felt, however, that development models of the weapon should be specifically identified, and it was decided to use the letter "X" as a prefix to show the experimental nature of the design. It was also decided to add the letter "T" to indicate--in the phraseology of the Committee's minutes--"the word 'tentative' or 'tiny' (or something)." Thus the weapon became known as TX-V (and, soon thereafter, the TX-5) and the Committee as the TX-5 Steering Committee. The adoption of this system set the pattern for many subsequent atomic devices.[9]

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[redacted] The possibilities of contact or even subsurface burst requirements were briefly considered, but it was felt that the basic design of an implosion weapon made anything but air burst impossible. DOE b(3)

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Computer time was scheduled, and it was hoped to have compression figures in about 3 months.[10] (Subsequently, due to the pressure of other computer programs, it was decided to interpolate, using other computational results.) The Steering Committee established a schedule calling for preliminary design by January 1, 1950, and complete design July 1, 1950. [redacted] DOE b(3)

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The contents of a December 10, 1948, letter from the AEC General Advisory Committee were discussed in the January 7, 1949, meeting of the TX-5 Steering Committee. This letter stated that reduction of size and weight of atomic weapons was vitally important to national defense and that the AEC wholeheartedly supported the aims of the Steering Committee in this regard. The Advisory Committee hoped that the new small weapon could be ready for production soon after proof-firing, and suggested that a substantial portion of the implosion stockpile in early 1950 be made up of the new bomb. The program was accordingly accelerated.[12]

Problems of nuclear safing had meanwhile been studied. The Sandia Research and Development Board (later renamed Sandia Weapons Development Board and, still later, Special Weapons Development Board) was a group including representatives from Sandia and the Armed Forces Special Weapons Project, the military organization formed to handle military problems connected with the atomic bomb. The Board held an initial meeting March 2, 1948, and suggested that design attention be paid to the possibility of extracting

Consideration was given to the necessity for duplicate bridge wires in each detonator. [redacted] DoE b(3)

The use of single bridge wires was then proposed, with two X-units connected in parallel to each bridge wire. This raised the question as to whether one X-unit would fire back through the other, rather than across the bridge wires, and it was eventually decided to provide one highly reliable X-unit and to use single bridge wires.

Initial Sandia mention of the new weapon was made in a progress report of February 18, 1949, wherein it was noted that SLE-7 had been organized as the FM Mk V Division.[18] This Division, in starting design work, was confronted with the general shortage of office and engineering space and facilities at Sandia, caused by the concurrent startup or expansion of other design projects.

Selection of aircraft to carry the TX-5 was discussed in the Steering Committee meeting April 8, 1949. The Air Force program was currently slanted toward use of heavy, long-range bombardment aircraft. Medium-size Navy bombers were still under design, and would not be in production for at least 2 years. Consequently, there was some feeling that current schedules might produce a new bomb before a suitable bomber became available.[19]

As a result of the above meeting, a TX-5 Ad Hoc Panel was appointed by the Military Lisison Committee May 12, 1949.[20] This Panel was composed of representatives of the three Services and, in the course of several meetings and discussions during the summer of 1949, came to feel that the [redacted] DoE b(3)

[redacted] discussed in the July 19, 1949, DoE b(3) meeting of the TX-5 Steering Committee. It was agreed that as small a diameter as practicable should be selected, since it would be relatively simple to scale upward. A suggestion was made that the bomb be made small enough to fit into a guided missile, but this appeared unduly restrictive. The diameter selected was enough of a departure from previous full-scale detonations to constitute a valid experiment in the laboratory sense, and yet was a size for which some compression computations had been made. [redacted]

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Throughout the rest of 1949, design studies were made of components such as inflight insertion mechanism, power supplies, and firing sets. Wind-tunnel tests were made of ballistic shapes, and studies made of possible asymmetries which might result from malfunctioning of one or more detonators. [redacted]

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The general subject of bomb size came in for considerable discussion. Some members of the Steering Committee pointed out that current Rand Corporation studies of nuclear weapons favored use of larger bombs. Other members felt that future emphasis on guided missiles would require small nuclear warheads, and the outcome was a decision to continue work on TX-5 with an eye to eventual stockpile production, but to place more emphasis on larger bombs.

The Military Liaison Committee studied the report of its TX-5 Ad Hoc Panel, and requested the Atomic Energy Commission to delay development of small weapons. The AEC responded with a statement emphasizing the need for small bombs, both to increase flexibility of atomic-weapon usage and to maximize possibility of successful weapon delivery by either aircraft or missiles. A letter to the Military Liaison Committee on January 3, 1950, stated that the General Advisory Committee of the AEC was in favor of developing small or tactical atomic devices and concluded that.

"The TX-5 project is one of the weapon developments in which the interest of the Atomic Energy Commission reflects a general concern that within the next few years the problem of successful delivery of atomic weapons may come to overshadow the problem of increasing the destructive potential of the weapons themselves. The Commission recognizes the primary responsibility of the using forces to set forth desired technical characteristics of weapons, as these characteristics bear on the delivery problem. The Commission remains anxious, however, that its best technical effort be contributed to a solution of this problem in all of its variants which impinge in the area of the Commission's responsibility. The Commission will therefore continue to keep you fully informed of prospective reductions in weapon size and weight, hoping that full advantage will be taken of these forecasts to ease the problems of development of future carriers, a field in which the development cycle is of course substantially longer than the usual cycle of development of the associated weapons."[22]

The Military Liaison Committee wrote to the Division of Military Application February 9, 1950, noting their belief that large-implosion-bomb performance could be considerably improved through use of nuclear design improvements produced by the TX-5 work, and stating that the smaller bomb should be reserved for use in guided missiles. [redacted] DoD b(1) The Division of Military Application stated, in a reply dated March 30, 1950, that the TX-5 nuclear design improvements might obviate any need for larger bombs, but agreed that higher priority would be assigned to use of the TX-5 with future guided missiles.[24]

The ballistic problem was by now well on the way to solution. Extensive experimentation had been undertaken, and a series of 28 different configurations of nose and tail designs had been tested in wind tunnels. A flat nose and large double-wedge fin tail were selected,[28] and the long slender shape of the TX-5 aided materially in producing an aerodynamically satisfactory product.

Deliberate oscillations were created in full-scale drops by use of rocket "kickers" attached to the bomb case, but these oscillations were quickly damped out by the inherent stability of the ballistic shape. A small fin tab was added to impart a slight rotation and improve the trajectory.[29] Weapons were released from various bombers under different conditions. Those dropped from a B-47 at high speeds and low altitudes experienced violent oscillations caused by the air flow around the bomb bay, which imparted a negative pitching moment to the bomb,[30] and this bomber was eventually eliminated as a TX-5 carrier.[31]

[redacted] DOE b(3) The Fission Weapon Committee of Los Alamos Scientific Laboratory met December 11, 1950, and proposed that experimental small-scale air bursts be detonated in Nevada. [redacted] DOE b(3)

Mk 5 production was now proceeding at full speed, but encountering procurement difficulties; and a Sandia letter to the Division of Military

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Application April 26, 1951, noted that even defense-order classifications could not assure deliveries of needed material and parts when competing with the country's defense buildup. It was concluded that: "It is only by almost superhuman efforts and the full cooperation from all quarters that we can, at this time, even think of delivering the Mk 5 Mod 0 weapon together with its ancillary equipment as early as February of 1952."[32]

The Mk 5 Mod 0 was released for production June 1, 1951.[33] The TX-5 Steering Committee (which had been renamed the TX-N Steering Committee on December 15, 1950, to reflect its broader interest in all implosion-type weapons) approved the design release and then severed its Mk 5 interests by concluding: "It is believed that the Committee's executive functions in the development of the Mk 5 Mod 0 are herewith completed except as specific changes in the weapon are brought to the Committee for approval."[34]

The Mk 5, as released to production June 1, 1951, was a free-fall, air-burst, implosion-type, radar-and-baro-fuzed strategic bomb. Its outside diameter was 43-3/4 inches; length, 128-1/2 inches; and weight, 3300 pounds.

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Due to the accelerated schedule, environmental tests were conducted on components, rather than complete weapons. Sandia completed its first assembly and inspection of a Mk 5 Mod 0 in March 1952, and released the weapon for operational service testing and military training. Stockpile entry started soon afterward.

During production of the early Mod 0 Bombs, some design changes were made that were incorporated in the early units. An investigation had been made of methods for quickly attaching and detaching the ~~rear case~~ center band segments (for purposes of weapon servicing), and it was decided to use trunk latches.[35]

The Armed Forces Special Weapons Project reported the existence of sneak circuits in the weapon junction box, and it was found that when the low-burst cable was used, there was a possibility that motor timer clutches could be

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unlatched during final assembly or postloading tests.[36] This could cause detonation if the weapon were subsequently released below the altitude at which the arming baro had been set; as a result, expedited investigation and action were undertaken. The low-burst cables were temporarily withdrawn, testers modified, and the low-burst capability restored in April 1952.

The Mk 5 Mod 0 Bomb was discussed in the August 6, 1952, meeting of the Special Weapons Development Board. It was noted that contact resistance of the baroswitches increased with age, but that this could be corrected by cleaning the contacts with solvent, changing the insulating material to eliminate an outgassing problem, and using gold alloy contacts. The inflight insertion mechanism had a tendency to overshoot and cause excessive wear, and a slipping clutch was added to correct this difficulty. The Board accepted the weapon for stockpiling, since corrective action was being taken on these items.[37]

The Mk 5 Mod 1 Bomb resulted from an Armed Forces Special Weapons Project request that cables to supply external power to heaters for batteries and radars be provided to maintain these items at operating temperature in cold weather. Stockpile production of the Mk 5 Mod 1 started November 1952.[38]

On October 13, 1953, Sandia suggested that the inflight insertion mechanism of the Mk 5 Bombs be reworked to incorporate all design changes that had been proposed in this apparatus. At the same time it was suggested that the cartridge mounting be altered to allow a bomb-to-warhead conversion capability, and this proposal was accepted. Design release was effected November 1953 and the revised weapon stockpiled in June 1954 as the Mk 5 Mod 2 Bomb.[39]

A considerable change to the Mk 5 Bomb was made in the Mod 3, which incorporated a new fuze. General dissatisfaction with the complexities of a radar fuze had caused Sandia to examine other methods, and an intensive study of this subject was instituted in mid-1951.[40] The simplest system would have been a pure barometric fuze, but this design had large inherent inaccuracies.[41] An impact fuze offered many advantages, including that of

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destruction of the bomb in the event the regular fuze failed, and much effort was expended on this device. This required the use of a fast-firing X-unit, and suitable design work was instituted.[42]

By the fall of 1952, a four-option fuzing system was being studied for Mk 5 application. This system included baro primary, radar primary, timer primary, and contact. Contact backup would be provided for the three air-burst options. The fuzing option would be selected during weapon assembly, through an access port in the skin of the bomb, by insertion of the proper plug in the top of the junction box.

A report on the above proposal was made to the Special Weapons Development Board September 10, 1952. Some members of the Board felt that remote selection of the fuzing option should be possible from the bomber while the weapon was being carried to the target, and other Board members requested that Sandia study the possibility of providing a fifth option, that of a baro-armed radar fuze.[43]

A proposal for a modification of the Mk 5 with the above five fuzing options, together with a suitable fast-firing X-unit, was forwarded to the Division of Military Application on October 22, 1952, and subsequently referred to the Military Liaison Committee.[44] The Committee, in their review of the proposal, requested deletion of the radar fuzing option and asked that inflight selectability be provided for the baro, timer and contact options. This requirement was discussed at the December 10, 1952, meeting of the Special Weapons Development Board, and it was agreed that the new fuze could be designed by May 1953.[45]

In the meantime, the concurrent development of many different fuzes for various weapons had generated concern, within both Sandia and the Armed Forces Special Weapons Project. By January 15, 1953, five such fuzes were currently under design for the Mks 5, 6, 7, 12 and 13. These fuzes required 30 different pieces of support equipment, and it was felt that this proliferation of gear would complicate training, operations, and

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logistics. Inasmuch as the Mks 5, 6 and 13 were strategic weapons designed for high-altitude bombing, it was suggested that the fuzes for these weapons be merged in a single design, called Fuze A. This could be a barocontact fuze with a safe-separation timer. The Mks 7 and 12 Bombs could be provided with a fuze for attack of tactical targets, and this would be called Fuze B, with primary fuzing a choice of radar, timer or contact.[46]

The subject was discussed in the January 21 and February 18, 1953, meetings of the Special Weapons Development Board, with a joint presentation being made by Field Command and Sandia Corporation.[47] It was pointed out that Fuze B was essentially the Mk 7 Mod 1 Fuze scheduled to enter stockpile in June 1953, and that this fuze would be available sooner than Fuze A. It was then decided that Fuze B would initially be used in the Mk 5 with a radar-fuzed air burst, pending availability of Fuze A, which would provide a contact capability.[48] The interim use of Fuze B was accepted by the Military Liaison Committee with some misgivings, as it was felt that the ultimate objective for the Mk 5 Bomb was elimination of radars in favor of baro fuzing.[49]

New bomb production requirements through mid-1955 were subsequently approved by the Secretary for Defense and transmitted to the Atomic Energy Commission May 15, 1953.[50] No new production of the Mk 5 Bomb was authorized, and concentration of effort on Fuze A for the Mk 5 was requested. Work on application of Fuze B to the Mk 5 was accordingly dropped, and a Mod change to the Mk 5 with Fuze A application was approved. This became the Mk 5 Mod 3 and was a baro-armed, baro-fuzed system, with contact backup. Mod 3 was design-released February 1954 and War Reserve entry was effected [redacted] The dimensions were the same as previous Mods, but the weight was reduced to 3025 pounds. This was the final modification on the Mk 5 Bomb design.

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GLOSSARY OF MK 5 TERMS

Armed Forces Special Weapons Project -- An interdepartmental agency formed to handle military functions relating to atomic weapons. Activated by memo order from the Secretaries of War and Navy, dated January 29, 1947. The Air Force was represented after passage of the National Security Act of July 29, 1947.

B-29 -- A heavy-bombardment-type, propeller-driven, four-engine aircraft.

Ballistics -- The science which studies the laws governing the motion of projectiles or of bombs dropped from aircraft.

Bridge Wires -- ~~High~~ Low-resistance wires in the detonator (which see) which~~, when~~ are subjected to a high voltage pulse from the weapon X-unit. ~~fuse and burst into flame, thus providing a means of detonating the high-explosive sphere.~~ These ignite the explosive elements of the detonator.

Capsule -- The nuclear ~~capsule~~ element of the weapon which, when subjected to compression in the implosion process, becomes supercritical and produces a nuclear reaction.

Committee on Atomic Energy -- Established by the Joint Research and Development Board (which see) in the summer of 1946.

Detonators -- ~~These contain the bridge wires (which see) which, when subjected to a sudden electrical load, burn rapidly and act as a match to apply a flame to various points on the outer surface of the high-explosive sphere (which see).~~ Explosive devices which when initiated (see bridge wires) by the X-unit ignite the lens charges of the high-explosive sphere (which see).

Division of Military Application -- An AEC office which functions as liaison between the Military and the weapons designers and producers. By provision of the Atomic Energy Act, the Director of this Division is an active member of the Armed Forces.

Fat Man -- Code name for the implosion weapon dropped on Nagasaki, Japan, during World War II. So named for its short, fat silhouette in contradistinction to the early gun-type weapon, which was called the Thin Man (later the Little Boy). The term was extended to include the general designs of early implosion weapons.

General Advisory Committee of the AEC -- The group established by the Atomic Energy Act to provide policy direction for the Atomic Energy Commission.

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High-Explosive Sphere -- The ball of high explosive that surrounds the nuclear pit and capsule and is designed to produce~~s~~ the implosion effect when detonated.

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Implosion-Type Bomb -- A weapon based on the principle discovered by Professor Charles E. Munroe, Washington, D. C. Written up in Scribner's Magazine and the American Journal of Science in 1888, and in Popular Science Monthly in 1900. Rediscovered by Egon Neumann of Germany, who took out German and English patents in 1910-11. The Munroe principle noted that an increased explosive effect was created when an unconfined cylinder of high explosive was hollowed out. In 1920 the Journal of the Society of Chemical Industry (London) stated that "no practical use has apparently been made of this discovery." Suggested by S. H. Neddermeyer at Los Alamos as a means for producing the extremely high pressures required on the capsule of an atomic bomb. Not much attention was paid to the suggestion until it received the backing of John von Neumann and George Kistiakowsky. The same principle was used in the Pacific area in World War II as a means for blasting the occupants of Japanese pill boxes, and for increasing the penetrating effect of shells and warheads.

Joint Research and Development Board -- A replacement for the wartime office of Scientific Research and Development. Established June 6, 1946, by Secretaries of War and Navy to carry on research and development work for new military weapons and equipment.

Kiloton Yield -- A means of measuring the effect of a nuclear explosion by comparing it with the effect of an explosion of TNT. A 1-kiloton yield is equivalent to the effect of 1000 tons of high explosive.

Los Alamos Scientific Laboratory -- Founded as the Los Alamos Laboratory in early 1943 as part of the Manhattan Engineer District to undertake weaponization efforts on nuclear devices.

Military Liaison Committee -- A committee established by the Atomic Energy Act of 1946 to advise and consult, on behalf of the Department of Defense, with the AEC on all atomic-energy matters relating to military applications of atomic weapons. Chairman can be any active or retired officer of the Armed Forces. Includes representative or representatives from each department of the Armed Forces.

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Rand -- Named for Research and Development. A corporation established by the Air Force in early 1946 to study future systems design.

Sandia Research and Development Board -- A joint Sandia Laboratory-Military board formed March 2, 1948, at Sandia Base to provide local guidance on weapons design.